Internatl. Pac. Halib. Comm.
Report

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REPORT OF THE INTERNATIONAL FISHERIES COMMISSION

APPOINTED UNDER THE TREATY BETWEEN THE UNITED STATES AND GREAT BRITAIN FOR THE PRESERVATION OF THE NORTHERN PACIFIC HALIBUT FISHERY

NUMBER 7

INVESTIGATIONS OF THE INTERNATIONAL FISHERIES COMMISSION TO DECEMBER 1930, AND THEIR BEARING ON REGULATION OF THE PACIFIC HALIBUT FISHERY

BY

JOHN PEASE BABCOCK, *Chairman*
WILLIAM A. FOUND MILLER FREEMAN
AND
HENRY O'MALLEY, *Commissioners*

SEATTLE, WASHINGTON
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FOREWORD

The present is a seventh report by the International Fisheries Commission upon its work under the terms of the Convention of 1924 between the United States and Great Britain for the preservation of the halibut fishery of the Northern Pacific Ocean, including Bering Sea.

This is in continuation of the first report of the commission in which it gave its recommendations for further regulation and a statement of the grounds upon which these were based. There are now transmitted and discussed scientific reports Numbers 2 to 6, bearing upon the commission's recommendations and upon the treaty by which it is proposed to put these recommendations into effect.

The International Fisheries Commission has had the help of an advisory board of four members: Dr. C. McLean Fraser, Dr. W. A. Clemens, Mr. N. B. Scofield, and the late Prof. John N. Cobb.

The investigations have been carried on by a staff under the direction of William F. Thompson, with headquarters and laboratory at the University of Washington, Seattle, U. S. A.

REPORTS BY THE INTERNATIONAL FISHERIES COMMISSION

1. Report of the International Fisheries Commission appointed under the Northern Pacific Halibut Treaty, by John Pease Babcock, Chairman, and William A. Found, Miller Freeman, and Henry O'Malley, Commissioners. Dominion of Canada, Ottawa, 1928.
   Same. Report of the British Columbia Commissioner of Fisheries for 1928, p. 58-76. Victoria, 1929.
   Same. Report of United States Commissioner of Fisheries for 1930, Appendix 1. U. S. Bureau of Fisheries Document No. 1073. Washington, 1930.
2. Life History of the Pacific Halibut (1) Marking Experiments, by William F. Thompson and William C. Herrington. Victoria, B. C., 1930.
3. Determination of the Chlorinity of Ocean Waters, by Thomas G. Thompson and Richard Van Cleve. Vancouver, B. C., 1930.
4. Hydrographic Sections and Calculated Currents in the Gulf of Alaska, 1927 and 1928, by George F. McEwen, Thomas G. Thompson, and Richard Van Cleve. Vancouver, B. C., 1930.
5. The History of the Pacific Halibut Fishery, by William F. Thompson and Norman L. Freeman. Vancouver, B. C., 1930.
6. Statistics of the Halibut Fishery (1) Changes in Yield of a Standardized Unit of Gear, by William F. Thompson, Harry A. Dunlop, and F. Heward Bell. In press.
7. Investigations of the International Fisheries Commission to December 1930, and their bearing on regulation of the Pacific halibut fishery, by John Pease Babcock, Chairman, William A. Found, Miller Freeman, and Henry O'Malley, Commissioners.

Further reports will bear serial numbers and will be issued separately by the commission.

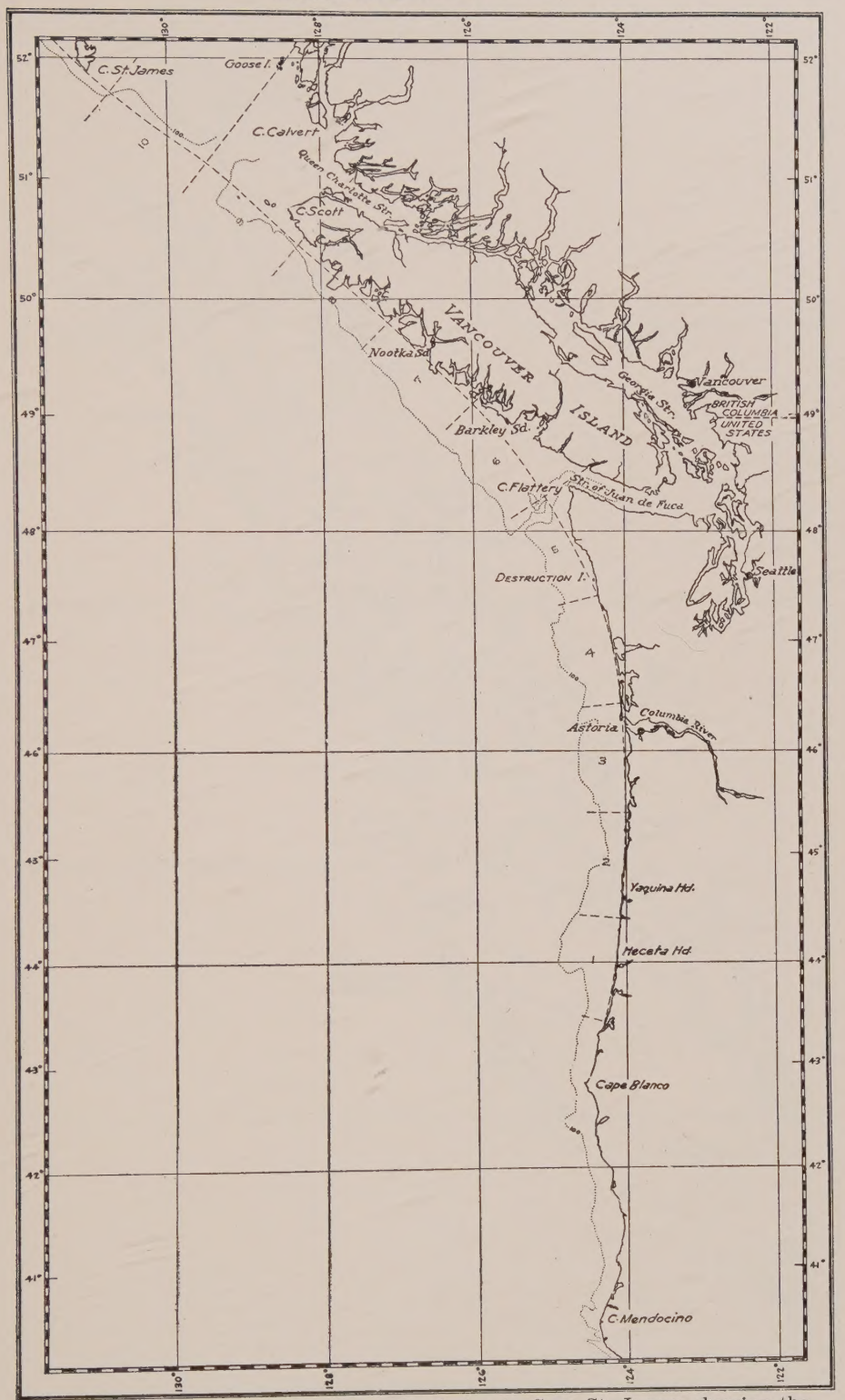

FIGURE 1.—Pacific Coast from Cape Mendocino to Cape St. James, showing the statistical areas by dotted lines.

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FUNCTION AND PROGRAM OF THE COMMISSION

The International Fisheries Commission, as established by the Northern Pacific Halibut Treaty, submitted in 1928 a report to the two Governments of Canada and the United States, embodying therein their recommendations for the control of the halibut fishery and summarizing their scientific findings in support. Since the submission of this report, the commission has prepared and has had printed five scientific memoirs which it now transmits. In response to the depleted condition which the commission has disclosed and to meet the recommendations made, the two Governments have prepared and have now under consideration a new treaty providing for powers adequate to put the recommended control into effect. This treaty has been approved by the Canadian Parliament and has been transmitted by the President to the Senate of the United States for approval. This present report[1] summarizes the work of the commission since the submission of the first report, substantiating its recommendations and showing the scientific basis which has been laid for control.

[1]The commission has had the assistance of the director of its scientific investigations, William F. Thompson, and of the scientific staff in the preparation of this report.

The present treaty provides for a closed season of three months, from November 16 to February 15, and for the appointment of the present commission of four members. It states: "The commission shall make a thorough investigation into the life history of the Pacific halibut" . . . "The commission shall report the results of its investigation to the two Governments and shall make recommendations as to the regulation of the halibut fishery of the North Pacific Ocean, including the Bering Sea, which may seem desirable for its preservation and development."

The duties outlined involve: First, as stated, a study of the life history; second, a system of statistical observation of the condition and trend of the fishery such as will indicate the regulations desirable; third, a knowledge of the fleet and its activities, such as will render recommendations practical and adequate. The commission has accordingly employed a scientific staff, chartered such vessels, and carried on such investigations as were necessary. These activities have been in part described in the first report in 1928. The organization and program of that year have been continued.

The task of carrying on a study of the life history of the halibut to a point where definite recommendations could be made for regulation has proved to be one of great magnitude and difficulty. This was to be expected as similar tasks with other species have proved so. Despite the earnest efforts for three decades of the many interested governments, particularly around the North Sea, fisheries science had not reached a stage at which the fundamental facts necessary for conservation of the halibut were available, nor were they for any other species to an extent sufficient to aid greatly in the problems met with. Moreover, the halibut fishery extends along the outer coast for a distance of over 2000 miles, and the investigations have necessarily been carried out at sea under most difficult conditions.

Yet certain circumstances have made exceptional progress possible. The species is well adapted to study in its biological characteristics, its distribution, and its fishery. There is but one method of the fishery, well defined and splendidly adapted to clear cut statistical observation of what is happening.

The men and fleet engaged are unusually homogeneous in type, and the fishery is carried on by nationals of the two Governments concerned. It is, moreover, the only marine fishery which is at present, or has any immediate prospect of being, under that international control which is a necessary preliminary to conservation. The treaty applies not merely under exceedingly fortunate conditions but is distinctive as a first step in international adjustment of the vexed question of high seas fisheries.

The commission is, for this reason, impressed with the importance of its task. Everywhere marine fisheries are expanding, and yet many of them obtain constantly diminishing returns. Depletion and possible commercial exhaustion are important and real economic problems to great populations. Yet nowhere are statistical means of observation sufficiently simple and adequate to indicate unmistakably what is happening, nor are the interested nations able to construct the machinery of

FIGURE 4.—Schooner type of halibut boat fishing to west of Cape Spencer.

FIGURE 5.—One of smaller halibut vessels fishing southern waters.

FIGURE 6.—Large female halibut from Hecate Strait.

co-operative regulation. The opportunity in the case of the present fishery is for these reasons uniquely favorable. It promises to the interests concerned returns from adequate conservation, and to the equally interested world the first complete observation of an intensive fishery and the first possible demonstration of the practicability of international control. Its fate is being closely watched, not only by the United States and Canada, but by the many foreign countries facing similar problems; not merely because of its local interest, but because of its bearing on marine fisheries everywhere and on the great problem of international co-operation.

The commercial importance of the halibut fishery is in itself sufficient to merit close attention, as is shown by the most recently obtainable figures of the catch. That affected by the present treaty is 57 per cent of the world's total. The value of the catch on the Pacific Coast of North America is between six and seven million dollars to the fishermen, and as sold by the cold storage firms and dealers, is several times this value. It is consequently one of the most important fisheries in North American waters.

	Pounds	Percentage
European fisheries (1928)	36,307,000	36.0
Atlantic Coasts of United States and Canada (1928)	6,095,779	6.0
Pacific Coasts of United States and Canada (1929)	57,692,595	57.1
Japan (Hokkaido, 1928)	871,488	.9
Total	100,966,862	100.0

The banks on which it is found are shown in Figures 1, 2, and 3. They are divided into areas each including 60 linear miles of trend of the coast line and the banks adjacent thereto. These are for statistical purposes. They are frequently referred to in the various reports but should not be confused with areas suggested for purposes of regulation. The areas are numbered from Cape Blanco on the coast of Oregon to 36 at Unimak Pass, 2,100 miles in all.

The halibut is a bottom species, found on the banks in depths of 15 to 150 fathoms, and occasionally to 400. It is caught by longlines set on the bottom and made up in units called skates, of 1800 feet, with short 5-foot lines set at 9 or 13-foot intervals, each carrying a hook. The vessels used are all powered, and range in size from skiffs to steamers 120 feet long (Figures 4 and 5), with crews of 2, 5, or even 30 men. Voyages lasting two or three weeks and extending as far as Unimak Pass are undertaken. The fish are cleaned upon capture, iced, and after sale are either re-iced and shipped fresh, or are frozen for storage. The market is continent wide, from New York or Montreal to San Francisco or Seattle.

The commission has continued its program of life history studies and statistical observation as outlined in its first report.

SYSTEM OF OBSERVATION OF THE FISHERY

The system of statistics is necessary to show the past history of the fishery so that its present condition and trend may be understood, and from it must be obtained the concrete knowledge of present conditions necessary in making regulations practical and effective. In the future a scientifically based system of statistical observation must be in operation if, among the conflict of interests, chaos is not to rule in all application and discussion of recommendations made. The commission has, therefore, placed great emphasis upon the development and maintenance of its system of statistical observation as the sole hope for sane control in the future. Its course in so doing is fortified and rendered inevitable by the experience of other nations with other fisheries, where dissentient opinion still rules in discussion of fundamentals.

In this system of statistics it has proved necessary to provide three categories of facts. First and most important, a record of the abundance of the species as it varies from year to year in the several stocks of fish of which the species consists. Second, the annual yield which results in each case from the several levels of abundance. Third, a record and analysis of the fleet, and of all those conditions which qualify the application of control, legal or economic. In the course of the following discussion of the experience of the commission in developing these statistics, it will be shown how regrettable it is that such a system of observation has not been in force in the past.

STATISTICS OF ABUNDANCE OF EACH STOCK OF FISH

The first category of facts, the abundance of the species as it varies from year to year, has been of prime interest to the commission and all concerned. It has from the beginning of the work formed a major object of investigation and its changes have been followed for each section of the banks, a result well worth the great amount of effort involved. Something of the results, showing the great decline on the older grounds, was presented in the first report. The commission has now carried its investigations on to a far more definite and usable point.

The abundance as it varied under the expanding fishery has been studied by slowly and painstakingly gathered records as kept in the log books of the fishing captains. These have been collected in astonishing numbers for years as far back as 1906 by patient inquiry and explanation of purposes. The catch per unit of gear fished has been determined from these for each bank, and a standard of comparison has been arrived at by a careful study of the changes in length and character of this gear. At the time of the first report by the commission, this record was incomplete and defective, and the gear used was not wholly expressed in terms of a standard unit. The complete report remedies these faults. It not merely substantiates the rate of decline, but shows the variations in this rate as corrected for changes in gear (Report Number 6).

This fall in abundance on the various sections of the coast cannot be understood without the historical background of the fishery. This has been reconstructed by the commission and published in a special report, transmitted with this as Number 5. Beginning in 1888, the southern grounds between Cape Flattery and Cape Ommaney in Southeastern Alaska were exploited until 1910, the fleet in the meantime growing in efficiency and size. Between 1910 and 1913, exploitation of the grounds to the north and along the eastern side of the Gulf of Alaska was begun. A temporary expansion to grounds farther westward in 1914 and 1915 was followed in the years immediately after 1918 by a contraction of the area fished, and by overproduction from known banks. Not until 1921 and 1923 was the march of expansion resumed on the heels of the introduction of Diesel engines. Reference must be made to the report for the many significant details of this history. It must suffice here to point out: first, that the fishery has persisted only by virtue of its constant expansion to new banks and by its increasing efficiency; second, that certain sections of the banks have been exposed to an intensive fishery for longer than others; and third, that the stock exploited on grounds new in 1913 was a virgin, untouched one. The relations of these stocks to others, their depletion and replacement by immigration or reproduction can be understood after other branches of the investigation have been reviewed.

The decline on the older banks south of Dixon Entrance, statistical areas 9 to 13 in particular, has continued since 1906, with no signs of slackening, from a catch of over 260 pounds per set of a unit of gear to 48 pounds. Figure 7 gives the catch per set of standardized gear from 1906 to 1929. The fall has been at an even rate since 1913. The banks in Southeastern Alaska show the same type of depletion.

On the banks to the north and west of Cape Spencer, areas 19 to 36, along what is known as central and western Alaska, the abundance has also fallen rapidly from 1914 to 1929 from above 220 pounds per unit to below 80, but not at an even rate. The decline for three sections of these western banks is shown in Figure 7. On all of these banks the fall shows the same characteristics distinguishing it from that of the older banks to the south. It was rapid until 1918, then slackened, or even ceased, until 1923 when the rapid fall was resumed. The similarity of this sequence of change in abundance on all these western banks is heightened by the striking fact that although the more distant ones, areas 29 to 36, have been but recently opened, the catch per unit there was originally not as high as would be expected from a virgin bank but began its decline at the then existing level in the longer exploited sections, areas 19 to 29. The abundance is more nearly the same in all western areas than would be expected if the banks were independent, and if the degree of depletion depended upon economic factors only. The evidence is understandable only in conjunction with the work on migration, which has demonstrated the free intermovement of the spawning population on all the banks from the Gulf of Alaska west, but very little interchange between the two groups of banks separated by Cape Spencer.

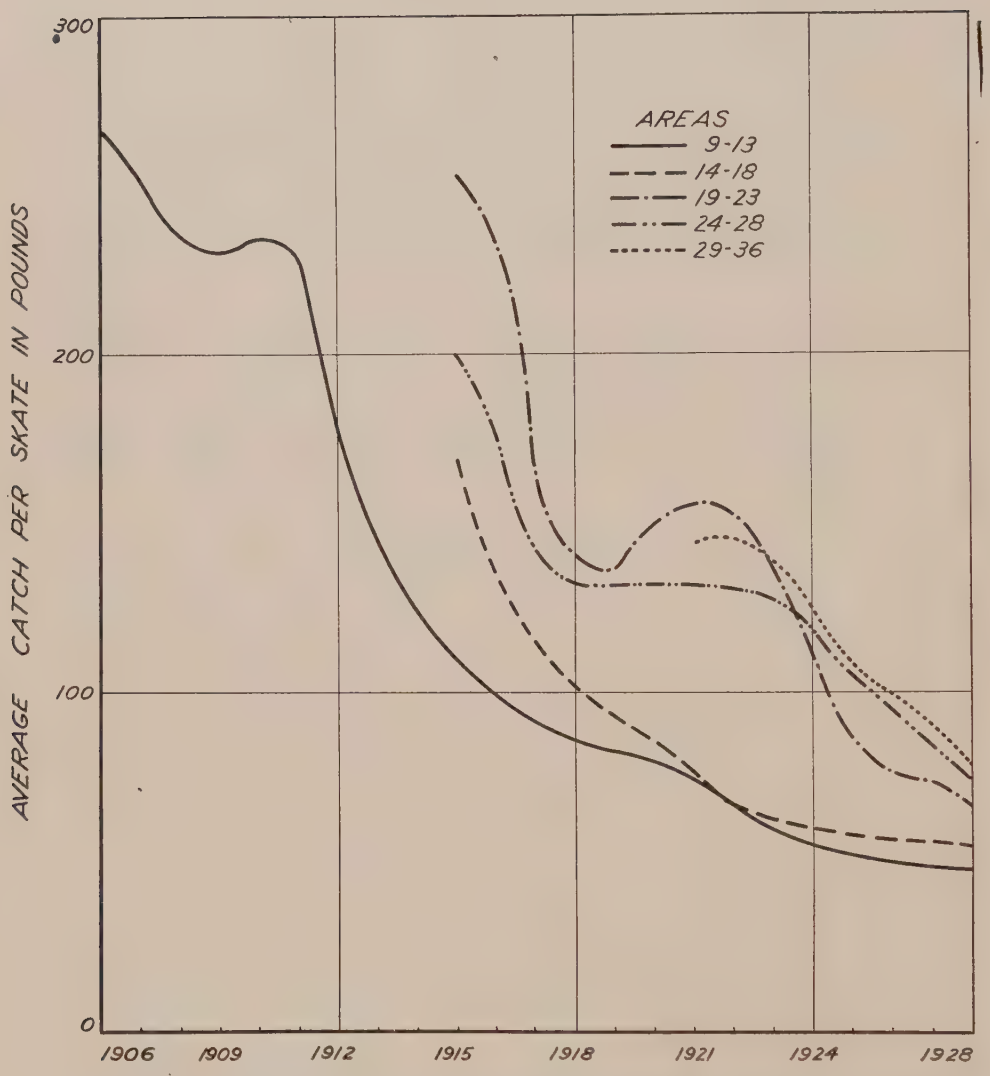

FIGURE 7.—Decline in average catch per set of a standard unit of gear. Areas 9 to 13, Vancouver Island to Dixon Entrance. Areas 14 to 18, Southeastern Alaska. Areas 19 to 23, Cape Spencer to Cape St. Elias. Areas 24 to 28, Cape St. Elias to Kodiak Island. Areas 29 to 36, Kodiak Island to Unalaska.

TOTAL YIELD FROM EACH STOCK

It is exceedingly regrettable that for past years it has been impossible to secure records which would show the total taken from the several areas, the second category of statistics necessary, since it is of vital interest to know how the decline in yield per unit set has affected the total catch.

The evidence at hand indicates that any level of abundance may become a stable one if the drain of the fishery will permit. The relative desirability of any such particular level of abundance is of course dependent upon the magnitude of the yield which can at the time be taken from the banks without untoward effects upon the stock. But this yield must logically depend upon the rate at which the fishery is then replacing its losses and this rate increases during at least the first stages of exploitation. A declining abundance is at first offset by a higher rate of replacement. But the commission knows of no way in which this can be ascertained save that of observing the total annual catches made as the fishery varies in abundance. The records of total taken from each stock then become of equal and parallel importance with those of abundance, and until the geographical range of each stock is known, the total must be obtained for each statistical area established.

The commission has carefully analyzed the total catch records of the past for the light they can throw upon the past yield of these stocks. The rather fragmentary evidence obtainable brings some hope that regulation can be successful in maintaining or restoring the yield at least in part.

As was indicated in the first report by the commission, while on the older banks the abundance has fallen to 16 per cent in 20 years, there is some basis for believing the total taken has decreased much less, to about 40 per cent. From this, it would seem that the species has shown an increased ability to replace its losses, although not sufficient to noticeably stem the depletion, and that in proportion to the relative levels of abundance, the stock now on the banks supports a larger fishery. Reason has been given for believing that this increase in rate of yield occurred during the first stages of depletion, so that during the more recent decline in the stocks on the banks there may have been no compensating increase in rate of replacement. If so, a much larger stock and higher level of abundance than now exists would proportionately increase the total available for annual use. The hope of successful regulation gained from this is strengthened by the temporary cessation of the decline between 1918 and 1923 on the western banks (Figure 7). This, we believe, was due to a temporary slackening of the fishery for the mature of the particular stock of fish concerned. But most unfortunately, we do not know to what extent this slackening reduced the total catch, so that no direct evidence exists as to what these banks can yield and still maintain the most desirable abundance.

Had adequate records of total taken from each region been kept in past years it is possible that the Governments would now have in hand knowledge as to what extent the catch must be curtailed. Under present conditions there is no alternative but to institute at once a competent system of statistical observation to give the neces-

sary records for the future. The need for this is emphasized by the fact that a closed season has already been in force and that other regulations are contemplated. Unless the effects of these are observed and recorded their results will remain vague and debatable.

The commission, faced with this necessity, has since the commencement of its work developed its system of observation in such way as to include a record both of the level of abundance and of the total taken annually from each statistical area as established for the study of records of abundance. Its returns, voluntarily given by the fleet, are now practically complete, and in case of passage of the proposed treaty, can be made entirely so. Due to the time required for the development of the system, the returns for 1926, 1927 and 1928 are partial only, the southern ports not having been covered by agents. But for the year 1929 the analysis is nearly complete and satisfactory. The details for this year are now in manuscript for publication. Figure 8 shows the total yield from each statistical area, and is illustrative of the data obtained. This yield has been analyzed according to season, size classes, vessels, and landing ports. It forms a secure basis for the necessary future observation of the fishery, in conjunction with equally complete records of catch per set of a standardized unit of gear in 1929. The latter continues the splendid series of records from 1906 to 1928.

In the statistics obtained to date, there has been no definite evidence visible of a beneficial effect following the imposition of the present closed season. This was also

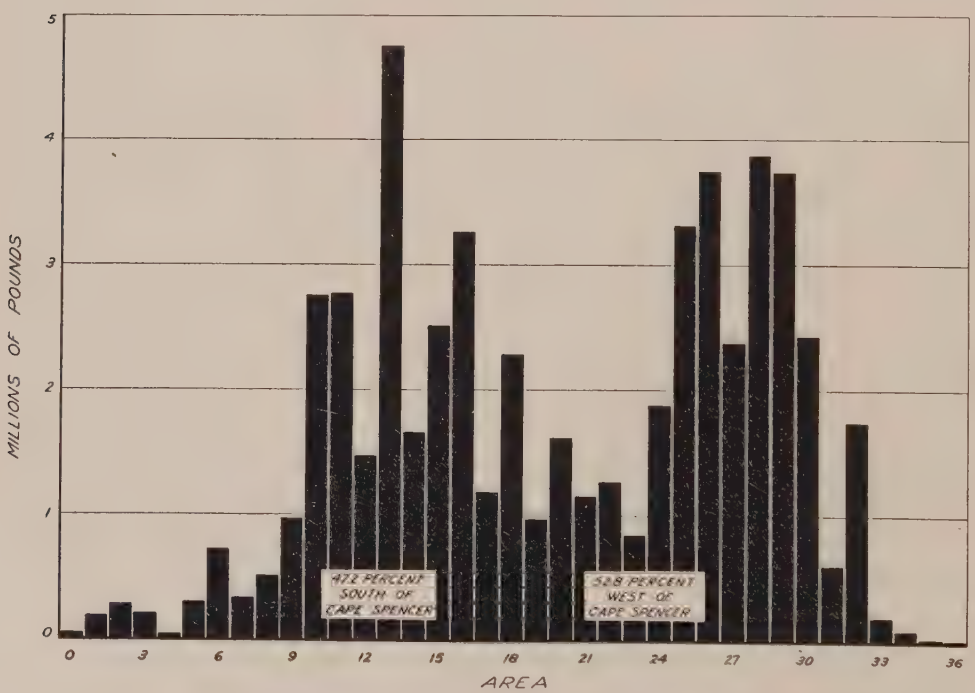

FIGURE 8.—Landings of the halibut fleet, both Canadian and United States, in 1929, according to area of origin, as shown in Figures 1, 2, and 3.

remarked upon in 1926, and the complete data of the more recent statistical report, Number 6, indicates the correctness of this conclusion. As previously stated, this does not indicate the failure of the closed season to protect the spawning fish at the time, but does indicate that this same stock is fished even more intensively at other seasons. It is logically to be expected that if any stock increases in numbers because of temporary or partial protection, it is correspondingly more intensively fished when available because such increased yields are aggressively sought by, and rarely escape, the fishermen. As a matter of fact, the total taken annually from the banks since the closure was inaugurated has exceeded that taken previously, as shown by the following figures, excluding California and Oregon. This is despite the continued decline in abundance. The conclusion of the commission that the closed season is advisable as far as it goes, but that it will not be effective from the standpoint of conservation until reinforced by further regulations, is but strengthened by the added evidence.

Five years average, 1919 to 1923	46,321,634 pounds
1924	53,058,558 pounds
1925	50,255,739 pounds
1926	52,531,612 pounds
1927	54,665,339 pounds
1928	54,192,055 pounds
1929	56,445,944 pounds

The commission also finds that since 1924 the fishery on the older banks has become more uniformly distributed over the open season (Figure 9). This may possibly be the indirect effect of the closure in steadying prices, but it may also be a more prolonged and steady effort upon the part of the fishermen to meet the declining yield per unit of gear. Other than this the fishery on these grounds has been little affected by the winter closure, as there has not been a winter fishery.

The commission has also carried out experiments upon the percentage of the stock removed yearly by the fishery. The results of these are given in Report Number 2. By means of the rate of return of marked fish, it is indicated that on the older banks, areas 9 to 13, there is in the neighborhood of 40 per cent of the commercial stock removed annually by the fishery in addition to the losses by natural mortality. Since from previous studies it is known that halibut appear in the commercial catch first at five years of age, and mature at approximately twelve, the seven intervening years account for the disappearance of the stock before spawning occurs to any extent. The experiments have not proceeded far enough to indicate the intensity of the fishery on western banks.

The statistics of catch also indicate that in the earlier years of exploitation on both old and new banks, the schooling of fish for spawning in late fall and winter was a prominent feature and was reflected in a higher catch per unit of gear at that time (Figure 10). With the passage of time and depletion of the stock, this

phenomenon is not so marked even on the newer banks and has nearly entirely disappeared on the older. There exists in areas 9 to 13 but a relatively small fishery for mature spawners on the outer coast. This evidence, although not direct observation of the fish, indicates that at one time the southern banks had their full quota of spawning schools, and corresponds to the other evidence of the history (Report Number 5). It shows that what is happening to the western banks has already happened to the southern, and that the latter at one time had a stock of mature fish.

Direct evidence of this change in proportion of matures and immatures is to be found in the increasing percentage of small fish called "chickens" by the trade, landed at principal ports (Figure 11).

The details of the statistics obtained may be found in the reports published (Numbers 1, 5, and 6) but others are in manuscript form and should appear during the current year.

The experience of the commission in preparing the report upon the changes in abundance, Number 6, indicates that in the future no difficulty will be met with in securing sufficient records each year of the catch per unit set of gear to indicate accurately the level of abundance in each area. It finds, however, that in case such records at any time become questionable, acceptable evidence as to changes in abundance can be secured although with greater difficulty, by an analysis of voyage lengths, catch per voyage, etc., rather than of gear.

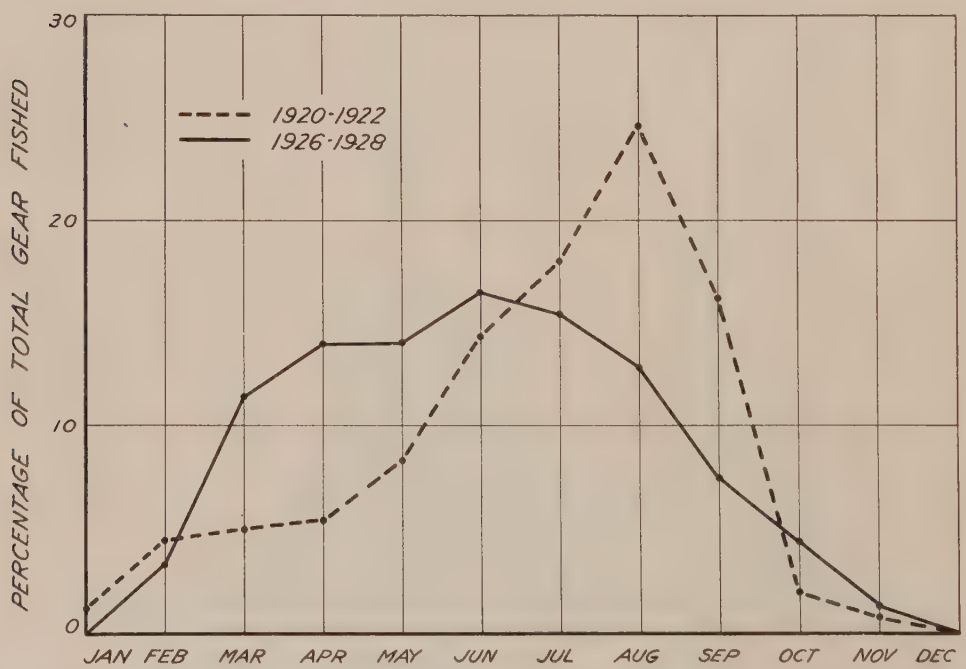

FIGURE 9.—Distribution of total fishing effort among the different months of the year on areas 9 to 13 before and after the closed season was inaugurated.

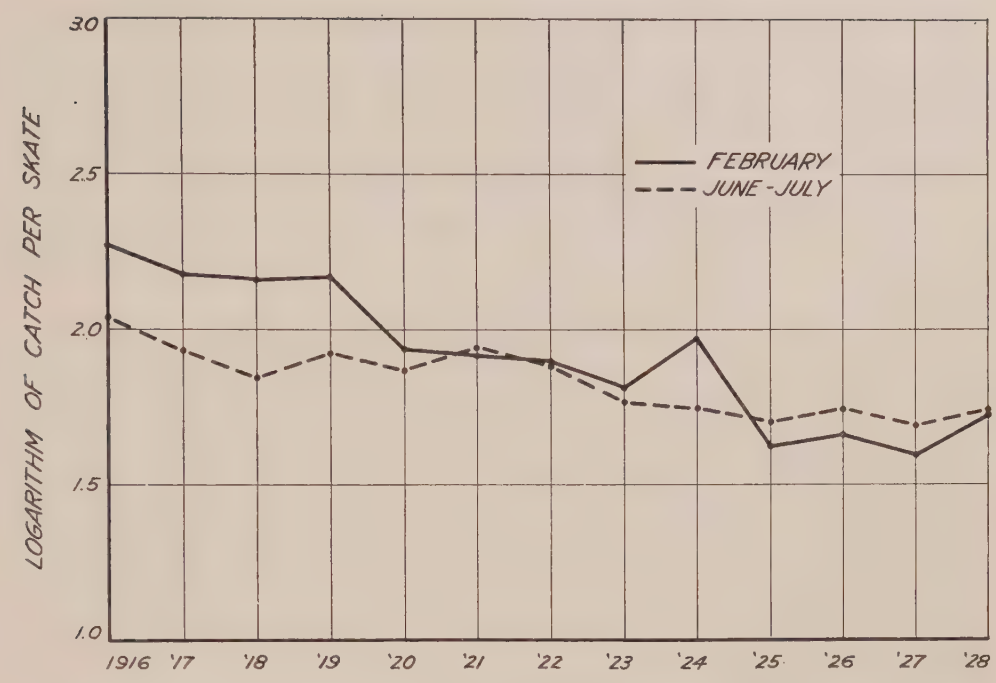

FIGURE 10.—Relative rates of decline in catch per set of a standard unit of gear during February and during June and July, to show former winter fishery for mature fish.

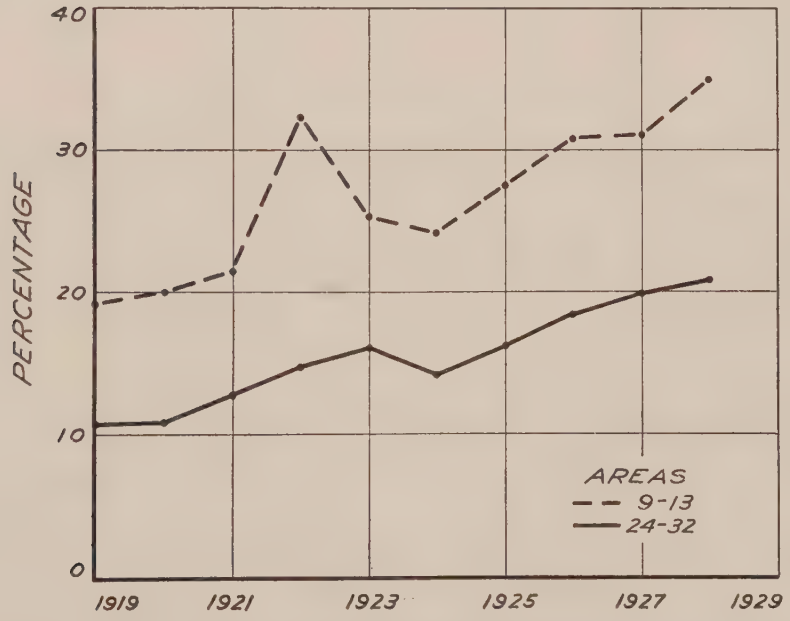

FIGURE 11.—Percentage of halibut under twelve pounds in catches landed from areas 9 to 13 and from areas 24 to 32 for the years 1919 to 1928.

There is however, equally as great a need for a record of the total catch by area which each level of abundance yields. This must be complete for practically the whole fleet or control is correspondingly faulty. The commission, under present conditions, finds this entirely possible to supply, since the whole fleet co-operates willingly. Such a summing up of the total yield, area by area, has been made for the year 1929, and is given in Figure 8. There is no reason under present conditions why this cannot be obtained for every year. The labor involved is however somewhat greater than need be. It could be decreased, and there should be provision caring for any chance adverse sentiment on the part of the fleet.

The labor can be lightened greatly and the results made more proof against error by collecting the data for less minutely divided areas. In fact, for purposes of the statistics required for regulation, zones including six to eight of the present statistical areas could be made. Many of the smaller boats habitually fish in but one of such zones, for which they should be required to clear, stating this on the clearance record both at the port of departure and on the vessel's papers so that they may be checked by patrolling vessels. Detailed log records would not be necessary from these numerous small vessels. This would relieve both commission and fishermen of much of the present detail, which would then be necessary only for those boats using more than one area or refusing to clear for but one region. Provision for this has been made in the new treaty.

The findings of the commission indicate, therefore, that this system of observation is a necessity, whether to observe the effect of new regulation, of the present closure, or of the lack of control, and that it is feasible to install it. The commission has proceeded on the basis that this work must be continued. If it is, the future changes in the yield of halibut will be defined and understood, and rational control will be possible.

ANALYSIS OF FLEET AND INDUSTRY

The practical nature of the regulations made as the result of the observation of the course of the fishery depends in large part on the comprehensiveness and accuracy with which the industry and the fleet are known, forming the third category of facts mentioned on page 14. In the report on the statistics for 1929, this information is given in detail, and under the system adopted can be obtained for any current year. The fleet is analyzed as to tonnage, gear, banks fished, landing ports, and catch. The landings are given by port and bank and price obtained.

The commission has, therefore, by its investigations, determined most important facts as to the condition of the fishery and its needs. The great decline in abundance on all parts of the banks, old and new, demonstrates the need for adequate and immediate additional regulation. The level of abundance which would prove most productive must be far higher than that now existent, since the supposed beneficial effects of decreased population on the banks have long ago ceased to be probable with a decline to below 16 per cent of the former abundance. The present closed season is not framed so as to conserve the fishery, and the additional regulations provided for under the new treaty are vital.

In addition to these findings the commission has inaugurated a system of observation, showing for each stock the changing levels of abundance and the yield obtained therefrom. This system must be maintained if the fishery is to be rationally dealt with, whether regulation is adopted immediately or not. The new treaty provides powers necessary for this maintenance.

LIFE HISTORY

The recommendations made by this commission in its first report have been effectively supported by the more recent investigations on the life history.

These investigations have demonstrated the existence of nearly independent stocks of fish, corresponding to natural divisions of the fishing fleet and therefore forming a logical and natural basis for regulation by areas, as recommended by the commission and as incorporated in the new treaty. The characteristics of these stocks as to age, spawning size, and the pelagic drift of the young have been described and correlated with the corresponding statistics.

As was stated in this previous report, the work has been on a number of different phases including the rate of growth, time of maturity, spawning habits, migration of younger stages, of mature, the drift of eggs and larvae, and racial characteristics. In order that the recommendations of the commission could be made at the earliest possible moment, all of these phases early received sufficient attention to indicate the first general broad conclusions. The more careful analysis since made has fortunately corroborated these preliminary conclusions and has added much that is equally important.

MIGRATION

Of all the phases of life history, the one of major importance is migration, or interchange between banks. This has been studied by means of marking experiments in which numbered metal tags were attached to live fish.

It will be noted that during consideration of the decline in abundance on the different banks, the interpretation depended upon the interrelations of the stocks concerned. The similarity of the decline on all the western banks and its dissimilarity to that on the southern can be interpreted only in light of the marking experiments. We must know the migrations to interpret the statistical returns. The two investigations, statistical and life history, have been completely interdependent on each other for interpretation and could not have been, nor can in the future, be carried on separately.

An important feature of the marking experiments has been the correlation of the returns with the characteristic distribution of the fishing intensity. It is well known that the movements of the fleet do not reflect the movements of the fish in general because the success of the fishery depends in part on other factors than the

abundance of fish, such as weather, distance, and markets. The returns from marking experiments have for these reasons been considered in terms of the chances of recovery given by the amount of gear used on the various banks. Thus failure to capture because no fishing was done has not been accepted as evidence of failure to migrate. The commission has therefore not considered the tagging returns of any significance until they were compared with the opportunities for recapture. In doing this the very extensive and detailed statistics of gear fished on each statistical area were indispensable. See Figures 14, 15, 16, and 17 of the report on tagging results.

The results of these marking experiments have been summarized in a preliminary way in the first report, and in more complete manner in the second. They should be compared with the analysis of the statistics of abundance, the sixth report, which gives some indication of the relationship of the stocks on various groups of banks both by the uneven rates of depletion and by the existence of different levels of abundance.

These marking results indicate that the immature fish, meaning thereby fish predominately less than eleven or twelve years of age, migrate but little and that in a way indicative of random scattering rather than definite movement. This scattering is principally within the individual banks. The average movement is but 22 miles, although occasional individuals travel as much as 500 miles, but not frequently enough to be of any importance or to disturb the average. This average movement increases but little from year to year.

On the other hand, mature fish travel widely, as shown by the experiments on western banks where the only considerable stock of spawners remains. Fish tagged along the eastern side of the Gulf of Alaska are returned from all banks westward, in the numbers expected from the fishing intensity, but very seldom from banks southward, although abundant chances for recapture exist there. The movement of these fish is hence free and rapid over all the banks from the Gulf of Alaska westward and reaches in its first year its full extent.

In view of these results, the uniform character of the decline on the southern banks is understandable as are the particular changes in rate of depletion on all the banks west of the Gulf of Alaska. Different stocks of fish were concerned from the beginning. In the southern areas only the resident stocks of young are left, so that the level of abundance may differ markedly from Cape Flattery to Cape Spencer. But on the western banks this has not been true, since mature migrants are yet abundant and form a unit stock along the long coast of central and western Alaska, declining in unison on nearby and distant sections. Whether the slow growth of the western fish will ever allow the fishery to come to a complete dependence on the immature resident stocks remains to be seen.

EGG AND LARVAL DRIFT

These findings as to the independence of the two general areas, west of Cape Spencer and south, are borne out by the work upon the drift of eggs and larvae which float freely with the currents. Prolonged search in southern waters has failed to

show more than an occasional egg or larva, whereas an abundance has been taken on western grounds everywhere west of Yakutat in the Gulf of Alaska. These abundant eggs and larvae on western grounds have as yet been traced only a small part of the way toward the depleted southern grounds despite net hauls distributed over the whole Gulf of Alaska. The searching of these net catches is a very considerable task, and the final results will not be available for some time to come.

So important was the possibility that eggs and larvae from the western grounds were sustaining the southern fishery, that the commission undertook an investigation of the currents in the Gulf of Alaska. The eggs are laid in the open water and float freely at some depth. The larvae do the same and are carried without resistance in the direction of the existing currents. These the commission has studied by three series of oceanographical stations across the Gulf of Alaska in successive years, finding that the drift is to the westward, hence away from the southern grounds. The results of these current studies have been published in Reports 3 and 4, and will form the subject of an additional report now in press, Number 8.

RACIAL AND GROWTH CHARACTERISTICS

As has already been reported, the racial and growth studies bear out these conclusions. The several stocks concerned have distinctive physical peculiarities and distinctive rates of growth. The rate of growth is of such importance that the results obtained may be given in somewhat more detail. Age has been determined by use of the otoliths, or ear bones, and scales which grow with the fish by addition of substance on previously deposited material. The character of the additions varying from season to season, much as those of a tree do, annual rings are formed which can be read after proper preparation.

Males grow much more slowly than females. The latter reach weights of 150 and 200 pounds, while the males rarely exceed 30 pounds, although in both sexes occasional fish exceed these weights. Fish from the southern banks such as Hecate Strait, grow much more rapidly than those from the western grounds. An eleven year old male from Dixon Entrance weighs over thirteen pounds, whereas on the western grounds it would weigh under eight pounds. In other words, the same aged fish is on the southern banks a "medium", or first class fish, whereas on the western grounds it is a "chicken," or undersized fish. Putting this fact in other words, an eight pound male chicken is on western grounds eleven years old, on southern grounds nine. For this reason the percentage of small sized fish taken on the banks does not indicate the relative maturity of the schools, and even in the actual spawning schools the males provide a fair percentage of chickens. The fishery, however, values more or less equally the same sized fish, and for this reason the stock on southern grounds is, and always will be, fished intensively for a younger fish, and the high intensity there must apply over a longer period of life than on western grounds before maturity is attained at the approximate age of twelve. The proportion reaching spawning size will therefore be far smaller on the southern grounds than on the western. If, using a rough estimate, but 40 per cent of the commercial sized stock on the older banks survives each year, approximately twenty-six fish

would reach an age of eleven on the western grounds, as compared to four on the southern. This is entirely aside from the fact that the cost of distant voyages will prevent as intensive fishing on western grounds. The conclusion seems logical that the southern grounds are in a much more precarious situation than the western because of the differing growth rates, and because of the economic reasons for a more intensive fishery on nearby grounds.

Our studies on growth rates therefore bear out the conclusion drawn from the study of physical peculiarities, from the study of egg and larval drift, from the statistics of depletion, and from the marking experiments, that the stocks on the grounds west of Cape Spencer are largely separate and are distinct in characteristics and needs from those to the south.

These findings as to relative condition of depletion, of independence of stocks, of distinctness of needs, and of exploiting interests, indicate emphatically the validity, and indeed necessity, of the first recommendation of the commission "that power be given proper governmental authorities: 1. (a) To establish areas, within each of which, if deemed necessary for the preservation of the fishery there, the total catch of halibut may be reduced."

SUMMARY

It will be pertinent here to summarize the findings of the commission which indicate the serious condition of the fishery on southern grounds. The great and ominous decline in abundance has already been proved. The study of the seasonal changes in early years, added to historical records, show that there was at one time a spawning stock on these banks which has almost entirely disappeared, leaving a predominantly immature stock. This is kept immature by the high intensity of the fishery, operating over a series of years before maturity is attained. There may be a slow drift of matures from the western fishery, but this can barely suffice, after the immigrating stock has accumulated for a few years, to support a small outer coast fishery. There is but a negligible number of eggs produced south of Cape Spencer, and our findings indicate that there cannot be many which drift down from the still abundant spawners off Central Alaska. It is fair to conclude, therefore, that at present the catch on the older grounds comes from the spawning stock of five to fifteen years ago, and that the available population for use in the next decade has already been largely determined. Not merely must care be taken that the stock is allowed to reproduce, but what is on hand must be made of the best possible use.

The commission finds that within these major groups of areas the stock is distributed unevenly as regards sex, size, and maturity, and that the seasons at which the several biological categories of fish appear differ. Thus upon the "nurseries" the "baby chickens" are over 70 per cent males. On the Yakutat spawning grounds the percentage of males, which average much smaller than the females, varies widely according to the season and bank, but in general less than 10 per cent of the fish under 12 pounds in weight are females, while of those over 25, 90 per cent are

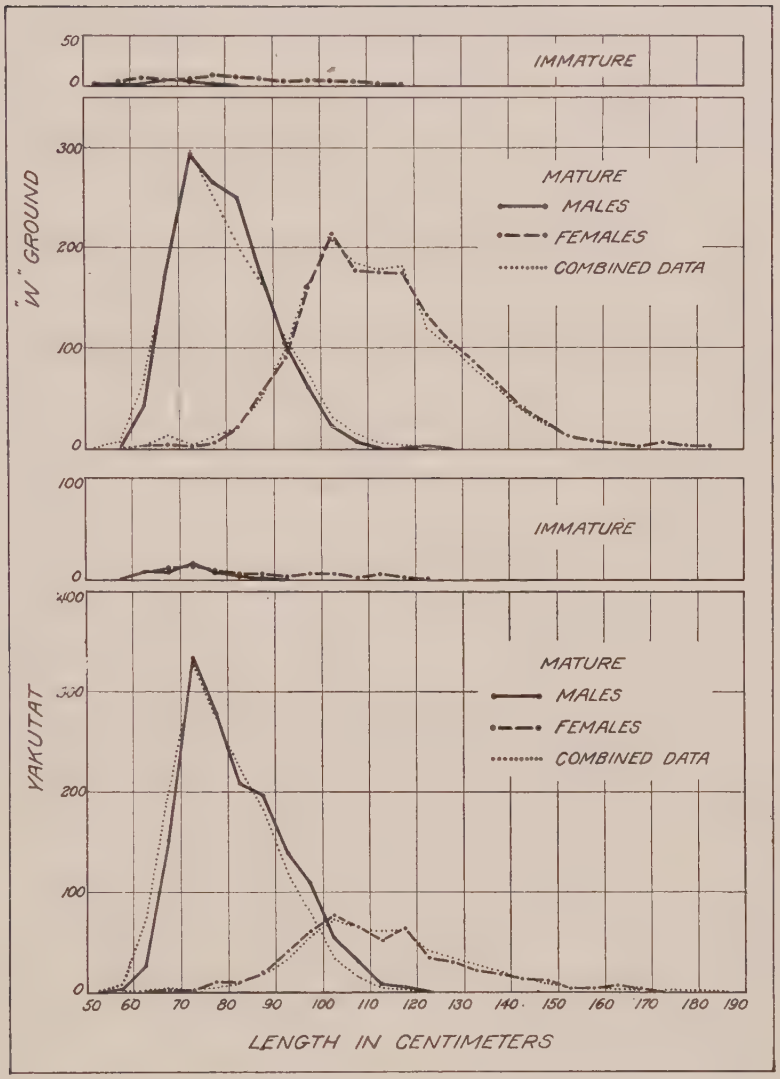

FIGURE 12.—Length frequencies of males and females, mature and immature, for halibut examined during the Yakutat and W Ground experiments. The light dotted line on each of the charts for mature represents the combined curve for all western experiments reduced to the same graphic range as the curve to which it is compared.

females (Figure 12). At different parts of the season the percentage of males, hence of chickens, varies widely, from 15 to 60 per cent of the total in the same general region. And it is well known that the percentage of mature varies from 0 to 100 per cent according to season and bank. The commission is as yet unable to present a complete picture of this complex distribution of different stocks. The regulations which must ultimately be adopted should, it is true, be based upon an accurate knowledge of this complex, and therefore must be flexible according to area. At present, restriction can only in part be guided by such detailed knowledge, and for some time to come these categories of the stock cannot be discriminated between, and restriction must be applied to the population of each regulatory area in general.

As stated in the first report and recommendations, the regulatory areas must be large, preferably but two—west and south of Cape Spencer. All our findings to the present support this division as a natural one for the fleet and for the species. The scientific work and the precision of our knowledge of the fleet encourages the belief that within the near future control can practicably discriminate between somewhat smaller areas, just as it is even now proposed to close small nursery areas off Masset and Timbered Islet. The discretionary powers provided for in the recommendations seem indispensable.

The recommendations of the commission, as stated in their first report and as embodied in the new treaty, follow logically and of necessity from the facts briefly reviewed here. It has been proved that the western and southern banks, separated at Cape Spencer, differ so completely in their stocks of halibut, in their fishing fleet, and in the condition of the banks, as to require separate regulation. It has been shown that, especially on the older banks, the amount removed each year is steadily reducing the several productive stocks, and that the very least which should be done on those banks already exploited to the full is to limit the present fleet to the steadily falling totals which the gear they now fish will bring from year to year. This the commission hopes will allow the fishery to come to an equilibrium without undue hardship on the present fleet. It has also been shown that a statistical system which will enable this to be done and which will properly observe the halibut fishery is a necessity and can be installed with advantage both to regulatory power and to fleet by providing for licensing and clearance. This control must be capable of meeting constant change on the part of the fleet and the fishery. It must be flexible and prompt.

The commission has, however, recommended specifically those methods of control which the industry favors. It has recommended that the areas populated by small immature halibut be closed permanently; that if it is found necessary, destructive gear be forbidden; and that the length of the present closure be extended two weeks with provision for a method of facilitating changes when this closure is found economically disastrous.

The scientific work of the commission and its careful consideration of conditions, leaves no doubt of the seriousness of the situation and the need for prompt and

adequate action. The opportunities for proper control are uniquely favorable, and ends to be served are important both to the local industries and to international co-operation in the conservation of marine resources.

In concluding, the commissioners desire respectfully to call the attention of their Governments to the continuance of the decline in this great fishery and to the need of prompt decisive action for rehabilitation.

(Signed)

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